

RAW MATERIALS

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STUDY OF THE TECHNOLOGICAL PROPERTIES OF KARELIAN ROCKS AS RAW MATERIAL FOR PRODUCTION OF MINERAL WOOL

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A technological study of basic and ultrabasic Karelian rocks as mineral wool raw material was conducted. It was found that ultrabasic rocks with a ratio of $\text{CaO} : \text{MgO} \geq 0.5$ are the optimum raw material for production of mineral wool by the cupola method. Promising sections of these types of rocks for development are identified.

Mineral wool, primarily fabricated from rocks from the gabbro-basalt group, is a heat- and sound-insulating material used in different branches of industry.

There are two basic methods of manufacturing this material: die-blowing (duplex process) and centrifugal with melting of the lump raw material in cupolas and processing of glass fibers with centrifuges. High-quality ultrafine mineral wool (fiber diameter of 1–5 μm) used for insulating different equipment but too expensive for use in construction is obtained with the first method. Basalt wool with a 6–8 μm (up to 10 μm) fiber diameter fabricated with the cupola method is used as construction material [1].

Basalt rocks without charge-adjusting agents are the raw material for production of mineral wool by the duplex method, and basalts with calcium-magnesium additives (limestones, dolomites, slags) are used for cupola melting [1–4].

The acidity ratio (oxide content: wt.%) is used to characterize the chemical composition of the glass fiber and raw material for manufacturing it:

$$M_a = \frac{\text{SiO}_2 + \text{Al}_2\text{O}_3}{\text{CaO} + \text{MgO}}.$$

The acidity ratio determines the melting point and viscosity of the melt. $M_a = 2.1–5.2$ is characteristic of fibers made with the duplex method and $M_a = 1.4–2.7$ is characteristic of fibers made by cupola melting. M_a decreases due to charge adjustments to the basic raw material.

Mineral wool tiles were manufactured by the cupola method in Kondopog in Karelia from 1979 to 1989 (KIMS plant). Khavch-zero pyroxene porphyrites ($M_a = 3.8$) with dolomitized Russkeal'skoe limestones were used as the raw material. The fine granularity, absence of inclusions of high-melting minerals (quartz, magnetite, olivine, etc.), the homogeneity of the chemical and mineral composition, and the ready fusibility are valuable properties of pyroxene porphyrites as raw material for basalt technologies (stone casting, mineral wool).

Porphyrite is currently supplied beyond the borders of Karelia for production of mineral wool both by the duplex method (Moscow, Lianozovo plant) and by the cupola method (Ryazan', TEKhNO Plant Ltd.).

The two-component batch for production of mineral wool by the cupola method is not optimum. The one-component batch is more economical as it allows simplifying the manufacturing process, decreasing the melting point, and increasing the output of the equipment. For this reason, studies were conducted at the Institute of Geology to find rocks with $M_a = 1.4–2.7$ in the territory of Karelia that could be used as one-component mineral wool raw material [5, 6]. Picrite basalts, pyroxenites, and gabbro-norites (Table 1) were investigated. The casting properties of melts at a temperature of 1350°C and their crystallization properties in pouring onto a metal slab and cooling in air were determined.

The studies showed that Samples 1–5 melt satisfactorily at 1350°C and have higher fluidity than the pyroxene porphyrite melt. Melts 1–4 solidify in the form of glass with no signs of crystallization. Melt 5 partially crystallizes, with separation of magnesium olivine. Sample 6 does not totally

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TABLE 1

Sample	Rock, sampling site	Mass content, %									M _a	CaO : MgO
		SiO ₂	TiO ₂	Al ₂ O ₃	FeO	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O		
1	Metapyroxenite, Khyursyulya	48.60	1.15	4.22	10.16	2.31	13.25	17.52	1.00	0.10	1.7	1.32
2	Amygdaloidal picrite basalt, Lindavaara	45.12	1.15	9.61	9.28	1.56	17.96	9.32	0.90	0.23	2.0	0.52
3	Clinopyroxenite, Tikshozero Massif, Shapkozero	45.60 –	0.60 –	2.60 –	5.70 –	0.70 –	17.17 –	16.40 –	0.35 –	0.07 –	1.4 –	0.76 –
		49.10	2.60	6.10	9.31	2.90	21.40	19.80	2.06	1.70	2.0	0.92
4	Clinopyroxenite, Tikshozero Massif, central section	44.80 –	2.50 –	8.80 –	6.70 –	4.40 –	8.40 –	16.00 –	1.30 –	0.15 –	1.6 –	1.90 –
		44.90	3.50	9.90	9.10	7.10	11.00	17.90	1.70	0.80	2.0	1.62
5	Massive picrite basalt, Lin'-gora	43.79	1.25	7.96	9.53	1.62	21.36	8.35	0.16	0.30	1.7	0.40
6	Gabbro-norite, Chernaya Salmi	48.36	0.42	8.78	9.32	1.62	20.96	8.12	1.10	0.25	1.9	0.39
7	Basalt, Sviyagino, Far East	42.24	–	13.85	–	14.20	13.83	12.96	0.83	0.99	2.1	0.93

melt, and relics of high-melting minerals (olivine, plagioclase, rhombic pyroxene) remain in the melt.

Process tests of the samples (1, 2, 5) were performed at the Research Institute of Heat Insulation (Vilnius) in comparison to Sviyazhsk basalt (see Table 1, Composition 7), which is recognized as one of the best kinds of raw material in melting in cupolas with hot blowing.

The melting point was determined with an MKhO-2 high-temperature microscope from Karl-Zeiss Jena on small bar samples 5 mm high and 3 mm in diameter, fabricated by semidry molding. The rate of heating the sample above 1000°C was 5 K/min. The duration of melting of the rocks was defined as the time of formation of a homogeneous melt at 1400°C from a sample weighing 50 g with a 0.25 – 1.00 mm grain size. The results of the tests are reported in Table 2.

According to the data obtained, Melts 1 and 2 are similar to the Sviyazhsk basalt with respect to the melting point, melting time, and crystallization temperature, but have a smaller processing temperature range ("shorter"). For this reason, bases that "lengthen" the melt are necessary for production of a fine fiber with an average diameter of 4 – 5 μm.

A standard fiber with a diameter of 6 – 8 μm can be obtained with no additives. With respect to the water-resistance index (pH = 2.5), the mineral fiber made from these melts is similar to the best foreign samples and is 3 times better than slag wool.

Composition 5 has a higher melting point and time. Crystallization of Melt 5 begins at a higher temperature due to separation of magnesium olivine, which decreases the processing temperature interval. Such melt processing features can make it difficult to obtain mineral fiber with the one-component scheme.

The experiments showed that the value of M_a is insufficient for evaluating rocks as mineral wool raw material. With close values of M_a, the compositions studied have different process properties as a function of the ratio of calcium and magnesium. The data in Table 1 show that ultrabasic rocks with CaO : MgO ≥ 0.5 are suitable for production of mineral wool with the one-component scheme. At a higher MgO content (CaO : MgO < 0.50, the raw material is high melting and has high crystallizability due to separation of olivine during cooling of the melt. These properties make it difficult to obtain quality glass fiber.

TABLE 2

Sample	Melting point, °C	Melting time, min	Viscosity, Pa · sec	Initial crystallization time, °C	Products of crystallization	Output temperature range, °C
1	1280	8	0.8	1250	Pyroxenes	150
2	1300	11	0.6	1250	"	150
5	1330	20	0.4	1300	Diopside, forsterite, hematite	100
7	1260	7	0.7	1200	Pyroxenes	200

* At 1400°C.

Of the rocks investigated, amygdaloidal picrite basalts and pyroxenites have the optimum $\text{CaO} : \text{MgO}$ ratio.

Picrite basalts appear in six sections within the boundaries of the Kondopoga region of Karelia. They form a series of lava flows and beds with a depth of 6 to 100 m which can be followed over hundreds of meters to several tens of kilometers [5]. Tikhshozero Massif clinopyroxenites are also of interest, especially from the central part where a large deposit of apatite carbonatites, recommended as raw material for multipurpose applications, is located [7].

The Karelian raw-material base for the mineral wool industry, currently based on use of pyroxene porphyrites from the Khavch-ozero deposit, can thus be expanded by developing sections of ultrabasic rocks (picrites, pyroxenites) which are promising as one-component raw material for production of mineral wool by the cupola method. Such raw material was found for the first time in the territory of European Russia.

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